CLiMET®
INSTRUMENTS COMPANY

Operator's Manual

CI-3100 Ethernet OPT sensor

Remote sensor
for continuous
particle counting

CI-3100–21-X-X-X
Ethernet Remote Sensor
OPERATOR'S MANUAL

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1 INTRODUCTION

1.1 CAUTION

THIS IS A CLASS 1 LASER DEVICE AS SHIPPED FROM THE FACTORY. NO LASER RADIATION FROM THE LASER DIODE IS ACCESSIBLE BY THE USER.

USE OF CONTROLS OR ADJUSTMENTS OF PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN MAY RESULT IN HAZARDOUS RADIATION EXPOSURE[1].

[1] Federal Register 21 CFR 1040.10 h iv J

1.2 TRADEMARK

Modbus is a trademark of Modicon, Inc. Industrial Automatic Systems

Ethernet is a trademark of Xerox Corporation USA.

1.3 PATENTS

The CI-3100-21 Ethernet Remote Sensor is protected by one or more or the following U.S. or Japanese patents:

US RE 37,353E

5,515,164

5,825,487

3327393 (Japan)

Other patents are pending.

1.4 SENSOR MODEL NUMBERING

This manual has the specification information for several different versions of this sensor. There are two standard flow rates for this sensor, 1.0 cubic feet per minute (CFM) and 0.1 CFM. This sensor has two size detection options: 0.5µm and 5.0µm; 0.3µm and 0.5µm. The CI-3100-21-X-X-X communicates on a 10/100Base-T Ethernet network using TCP/IP protocol.

When using this manual please refer to only the options which pertain to the particular sensor in question. To determine the configuration of the sensor refer to the model number label on the bottom of the sensor. The model number has the following format:

CI-3100 – W – X – Y – Z

Where:

- **W** ⇨ Family Options
  21 = Ethernet Sensor model family with Ethernet Connectivity.

- **X** ⇨ Voltage Options
  1 = 115VAC 60 Hz; US Power Cord.
  2 = 230VAC 50 Hz; European Power Cord.
  3 = 240VAC 50 Hz; United Kingdom Power Cord.

- **Y** ⇨ Size Sensitivity Options
  2 = 0.5µm and 5.0µm particle channels with 30mW Opnext LD.
  4 = 0.5µm and 5.0µm particle channels with 50mW Opnext (or Sharp)
  6 = 0.3µm and 0.5µm particle channels with 50mW Opnext

- **Z** ⇨ Flow Rate Options
  6 = 1.0 Cubic Foot per Minute (CFM) sample flow rate with filtered external exhaust.
  7 = 0.1.Cubic Foot per Minute (CFM) sample flow rate with filtered external exhaust.

Example:

A model number of CI-3100-21-1-4-6 would have 115 VAC 60 Hz power and Ethernet connectivity through RJ-45 connector on the rear panel of the unit, a size sensitivity of 0.5µm and 5.0µm, and a sample flow rate of 1.0 CFM with filtered external exhaust.

1.5 GENERAL DESCRIPTION

The Climet Model CI-3100-21-X-X-X is a microcontroller based remote two channel Airborne Particle Sensor. It is configured for integration into an Ethernet 10/100Base-T network using TCP/IP protocol. It is designed for use in a cleanroom facility monitoring system, or other process environments where particle contamination is controlled or monitored.

There are five visual indicators on the front of the unit: Power, Alarm, Count, Laser Status, and Flow Status.

The CI-3100-21-X-X-X is powered by a universal input power supply that will accept AC voltage from 100 to 240 VAC, 50/60 Hz. Two connections are made to the unit at its rear panel: a power cord (supplied with the unit), and a CAT 5 cable.

Particles are sized greater than 0.5µm and 5.0µm (or 0.3µm and 0.5µm for the -6). The standard flow rate is 1.0 cubic feet per minute, which limits the allowable concentration of particles to 1 million per cubic foot or 35.3 million per cubic meter. The sample volume can be collected in cubic foot mode (CF) or in cubic meter mode (CM). The sample time for the CF mode is 1 minute while the sample time for the CM mode is 35.3 minutes.

NOTE: The 0.1 CFM models have 1/10th the sample volume therefore a concentration limit 10 times greater.

Communications with the unit must use the Modbus protocol within the TCP/IP protocol (known as Modbus over Ethernet) or using the HTTP Web Pages within the unit (see section 4.3 for Web Page communications).

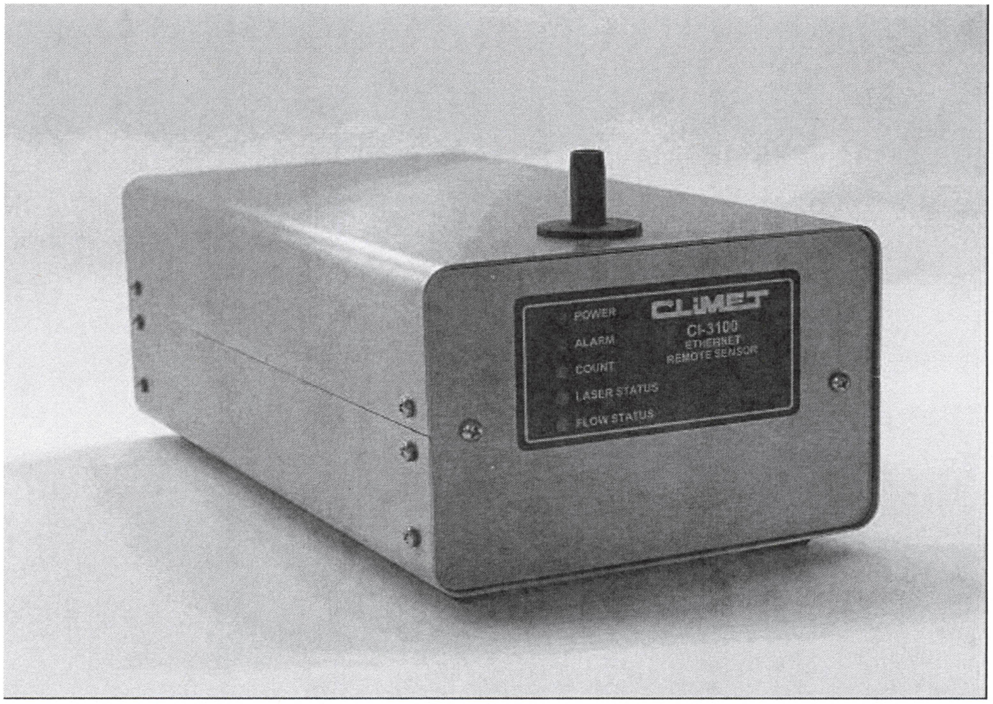


Figure 1 - CI-3100-21 Ethernet Remote Sensor

1.6 0.1 CFM Models

It is important to note the differences for the 0.1 CFM flow rate options. In particular, the counts reported by these models will be the counts from 1/10th of the sample volume. The sample time will remain constant.

The "Status Word" contains a bit (#29) that is set to 1 for the 0.1 CFM models. This bit will remain zero for the standard 1 CFM flowrate.

Data acquisition software must take into account the different sample volume if the data from a 1 CFM unit it to be correlated with the data from a 0.1 CFM unit.

The configuration utility has a choice of sample volume that is shown as either 1 CM (m^3) or 1 CF (ft^3). This setting simply sets the sample time over which the OPT will collect count data. Selecting 1 CF sets a sample time of 1 min and a sample volume 0.1 CF. Selecting 1 CM sets a sample time of 35.3 min and a sample volume of 0.1 CM.

****

NOTE:

0.1 CFM models report counts for sample volumes that are **1/10th** that of a 1.0 CFM unit.

****

1.7 SPECIFICATIONS

Illumination Source:	Laser Diode, 50 mW max. (Class 1 Laser Device)
Optics:	Elliptical Mirror (Patent # 5,467,189)
Size Sensitivity:	0.5µm and 5.0µm * 0.3µm and 0.5µm
Count Efficiency:	50% ± 10% at 0.5µm, 100% ± 10% at 0.8µm * 50% ± 10% at 0.3µm, 100% ± 10% at 0.5µm
Concentration Limit:	1.0 X 10^6 Particles/FT^3 (35.3 X 10^6 Particles/M^3) *1.0 X 10^7 Particles/FT^3 (35.3 X 10^7 Particles/M^3)
Max FCR Count Rate:	7.1 per CM >0.3 µm(95% UCL) per ISO 21501-4 * 71 per CM >0.3 µm(95% UCL) per ISO 21501-4 (1 count per five minutes)
Calibration:	Factory prime calibration with NIST traceable standards in accordance with ISO 21501-4
Sample Flow Rate:	1.0 Cubic Feet per Minute * 0.1 Cubic Feet per Minute
Flow Rate Control:	Electronic, automatic closed loop
Sample Tube Extension:	3/8" (9.525 mm) I.D. * 1/4 (6.35 mm) I.D. 20 ft. (6.1 meters) max length
Flow Rate Indicator:	Mass Flow Cell with LED indicator
Display:	LED Power, Alarm, Count, Flow Status, and Laser Status
Network Interface:	Ethernet™ 10/100Base-T (auto sensing), half or full duplex (auto sensing), Modbus™ on TCP/IP; HTTP capable
Sample Volume:	1 cubic foot or 1 cubic meter. Usual sample times are 60 seconds or 2118.88 seconds, but may increase based on flow and laser status during the sample. Sample data updated once per sample volume continuously; rolling and interval data updated 60 times per volume (nominally every second or every 35.3 seconds). * **0.1 CFM Models:** The sample time is the same but the volume sampled is 1/10th
Dimensions:	6" x 4" x 11.50" (15.24 x 10.16 x 29.21 cm)
Weight:	7.25 lbs (3.29 kg)
Power:	100 to 240 V~, 50/60 Hz, Running power: 15VA Max
Fuses:	T250V 1.25A "Slow Blow", 5x20 mm (Two)

Operating Temperature:	32 - 100°F, 0 - 37.8°C
Storage Temperature:	32 - 155°F, 0 - 68.3°C
Humidity:	0 - 100%, non-condensing
Recommended Cable:	Category 5 unshielded twisted pair patch cable

Specifications with a (*):
Denote a specification that is dependent on model.

2 UNPACKING AND SAFETY

2.1 UNPACKING

This Climet Remote Particle Sensor was carefully tested and packaged prior to shipment and does not contain any internal packing materials. This unit is shipped in a special packing box designed to meet the National Safety Transit Association requirements for standard freight transportation. The packaging materials should be saved in order to prevent damage in reshipment should it become necessary.

Inspect the CI-3100 for damage received during shipping. If any damage is apparent, advise Climet and file a claim with the freight company.

2.2 SAFETY CONSIDERATIONS

The CI-3100 is a Class One Laser Product and contains a red, 50 mW maximum output laser diode. There is no possibility of exposure to laser radiation during the normal operation of this instrument as directed in this manual. Do not disassemble the particle sensor, as you may be exposed to laser radiation.

The power cord that comes with the unit must be used to power the remote sensor. The remote sensor is connected to earth ground through the power cord. Using a power cord without a ground wire will disconnect the AC mains from earth ground.

2.3 POWER REQUIREMENTS — LOCAL AC POWER

This unit requires 100-240 VAC 50/60 Hz supplied to the power entry module on the rear panel of the unit.

A power cord with the proper plug for the voltage and region is provided.

3 INPUT AND OUTPUT

3.1 GENERAL INFORMATION

The CI-3100-21 remote sensor uses the industry standard Ethernet Modbus protocol to communicate its data to the outside world. This means that the data is organized into data holding registers and coils. The data is organized into 32 bit double registers in order to store the particle counts at their greatest concentration. For conformity, all of the data from the sensor is stored in 32 bit double registers. See the chapters at the end of the manual for the complete register listing.

The Ethernet Modbus communication is at an auto sensing 10/100 Mbps data rate, supporting half-duplex and full-duplex modes (also auto sensing). It conforms to the IEEE 802.3 standard. This means that the particle counter can be connected to the computer network in your office or factory—no special cabling is required, and you can choose among several software options.

The particle counter samples air at a fixed rate. The size of the air sample is therefore determined simply by how long the measurement interval happens to be. The particle counter measures the air flow rate continuously, and regulates the blower to keep the air flow within strict limits. If the blower is unable to properly regulate air flow, the sample status will indicate a flow error.

The CI-3100-21 provides two groups of data registers. Under normal operation the unit provides actual counts from the actual holding registers in the particle sensor. This is the power on default mode of operation. For system validation, a Forced Data Mode is provided. This mode allows the unit to be programmed with forced data in the forced holding registers to quickly test reports, alarm limits, etc, during validation of data acquisition systems. During Forced Data Mode, the actual counts and status values are not sent, instead, the values set in the forced registers are mirrored into the actual registers. The Actual count values are kept current in the sensor and once Forced Data Mode is cleared, the actual counts will be displayed.

3.2 OPERATIONAL DETAILS

The remote sensor will start to update data into the output registers only after it has received a signal to activate and start sampling (assuming that the particle counter has been connected to the power line, and the power switch has been turned on). Conversely, it will continue to run until it receives a signal to stop, or until the power is removed. Cycling power will not turn the sampling off.

3.2.1 A Sample Collected

NOTE: 0.1 CFM Models report counts in the same time intervals but the volume of air sampled is 1/10th that of a 1 CFM unit.

On a continuous basis, under good laser and flow status conditions for the complete sample volume, the remote sensor counts particles for 1 minute in 1 ft^3 mode, or for 35 minutes and 18.88 seconds in 1 m^3 mode. These particle counts from the last sample volume are stored in memory, along with laser

status and flow status readings from this last volume, when the remote sensor has collected the required sample volume. These counts are designated as the "sample" data counts. The sensor then immediately begins another sample volume.

Under the surface, however, there is a lot more going on in the particle counter. In order to monitor the air flow and laser power "continuously", these quantities must be examined much more frequently than at the end of each sample.

3.2.2 Subsample Intervals

The remote sensor also updates and stores in memory, 60 times more frequently than the full sample volume, what are called "interval" counts. These counts are similar to the sample counts but are only based on 1/60th of the total sample volume. At the end of each interval, the 60 interval counts that are stored in memory are totalized and stored into data registers.

The totalized counts are called "rolling counts". The rolling count data values represent concentration of particles over a continuous sample volume, not an increasing number of particles for the current sample. This rolling count is more indicative of the immediate conditions since it reports the particle concentration in the most recent sample volume updated 60 times more frequently than the sample counts. Use of rolling counts can be an advantage when sampling in cubic meter mode.

Similarly, the laser and flow status readings consist of sample, interval, and current sample parts. The sample status applies to the latest completed stored sample volume and consists of summarized laser and flow performance (known as sample status), plus average flow for the completed sample.

The interval portion of the laser and flow status is similar to the sample status but pertains to the last completed interval of the sample. The interval status is most helpful when sampling in cubic meter mode. The current portion of the laser and flow status readings applies to the sample or interval that is currently in progress and is updated 4 times per second whether in cubic foot or cubic meter mode.

3.2.3 Qualified Storage

The interval counts are only stored into memory when the laser and flow status for the just completed interval were good throughout the interval. This makes sure that the data stored in the interval memory locations were collected with the laser at the correct power level and the flow through the sensor at nominal levels.

If the laser power or sample flow is outside of their nominal ranges, the collected counts are thus suspect. So, in order to report good accurate particle counts, the current interval is stopped when either the laser or flow status is outside its operating window for 2 consecutive seconds. The interval timing will resume when both the laser and flow status are back within nominal ranges.

When the counts are stored into the interval counters the status bits in the status registers will reflect the bad status condition during the last interval.

Similarly, when the sample volume has completed, the status bits for the sample data will also reflect that the status was bad during the last sample volume.

This method of storage will lengthen the time that it takes to collect a full sample volume. If, for example, the sample flow was low for five consecutive seconds during the sample period, in CF mode it would take 63 seconds to store the sample data into the registers rather than 60 seconds. On the other hand, this method also provides the benefit of notifying the operator of a sampling problem almost immediately, and preserves valid subsample, intervals in the event that the sampling problem can be corrected quickly, resulting in minimal sample loss.

3.2.4 Determining the Operating Status

The unit also utilizes 3 counters, a sample counter, an interval counter, and a sentinel counter. The value of each is included as part of the available real data. The sample counter increments at the completion of every completed sample volume. The interval counter increments at the end of every completed interval (1/60) of a sample volume. The sample and interval counters will reset to zero with the following conditions:

- Reset upon power up
- Active to Standby mode transition
  (it will not reset if the unit is already active when it receives the active command)
- The 1m^3 sample volume to 1 ft^3 sample volume transition
  (it will not reset if the sample volume already is 1 ft^3 when it receives the command)
- Reception of the clear counters and reset sample timer command
- When the counters have reached the maximum allowed count in the 32 bit register (2^{32} – 1, sentinel counter included)

3.2.5 The Sentinel Counter

The sentinel counter is active any time the unit is electrically powered and increments every quarter second. It is reset to zero upon power up. Its value divided by 4 can be used as the elapsed time in seconds since power up. Since this counter will not roll over for 34 years (nor overflow to a negative value for 17 years if it is being read as a signed integer), it is a reliable tell-tale.

It also serves as an indicator that the unit is positively responding to requests to send data. This can confirm that the unit is operating properly even if the unit is polled for data multiple times between updates, in which case the data does not change except for the sentinel counter.

3.2.6 Forced Data Mode

Forced Data Mode allows the unit to simulate counts and sensor status for data acquisition system validation.

To activate Forced Data Mode use the *Coil 2 On* command to enable Forced Data Mode. Sending the Coil 2 Off command will return the unit to actual data mode. Forced Data Mode is only active when set by the Coil 2 on command. Cycling power will clear the Forced Data Mode and the unit will send actual data in the actual holding registers until Forced Data Mode is enabled again.

NOTE: In Forced Data Mode, the actual holding registers are a mirrored set of the forced holding registers. The actual holding registers are not updated with actual values while in Forced Data Mode.

The forced holding registers are an exact set of 32 bit binary actual holding registers (16 bit register pairs) that hold the rolling, sample, and interval binary counts, average flow, and status of the sensor, but are located at an upper address range from the actual holding registers in the unit. While in Forced Data Mode, values written to the forced holding registers will be returned in the actual holding registers. These forced holding registers are used for testing and validation, using the sensor and a validation process to generate known count, flow, and status values. These forced holding registers eliminate the need for sensor simulators during the testing and validation phases of the installation. CLiMET Instruments offers the Validation Utility which provides seamless control of the forced holding registers to test and validate data acquisition software. See chapters 5-8 at the end of this manual for the complete details and address listing of the holding registers.

3.2.7 Control Inputs (Coils)

The sensor also has three Modbus coils that control the sensor's sampling mode, forced count mode, and temporary cubic foot mode. The sensor sampling mode coil is used to turn the sensor from standby to active mode and from active to standby mode.

In 'standby' mode the sample pump and laser are turned off, while 'active' mode turns them on and starts the sampling process.

The forced count mode coil, when active, allows what the user has already written into the forced registers of the sensor be seen as the data in the standard data registers of the sensor.

The temporary cubic foot mode coil is used when the sensor is set to cubic meter sampling and needs to be calibrated with cubic foot data. See Chapter 8 of this manual for the complete address listing of the coils.

3.2.8 Retrieving Data

When the unit receives a Modbus command to send data from any industry standard Ethernet Modbus driver, it will transmit back to the host the values contained in the requested holding registers. The driver should be set to sample the holding registers at approximately twice their update rate. For CM mode, the rolling counts will update every 35.3 seconds and the sample data will update every 35.3 minutes providing that the laser and flow status remain good throughout the sample period.

The status register, however, should be sampled more often than particle count registers. By sampling the status register every 5 to 10 seconds the operator

can see fault conditions faster than waiting for the end of the interval or the end of the sample. The current status bits of the register give the current conditions of the laser and flow, and whether the unit is counting or not (due to a fault).

3.2.9 Modbus Addressing

The order of the holding registers are listed in the appendices. The remote sensor has been designed and tested using the 5-digit Modbus Generic PLC Protocol. The holding registers for this type of protocol start at address 40001 and the coils start at 1. So, for the rolling small particle counts that are currently stored in memory the operator needs to request data from "40001 L" to get the two registers that hold this count. Note, the "L" signifies a 32 bit register. The sample data for the small particles will be at "40013 L". The Status Registers will be at registers 40005 and 40006. These status registers can be accessed bitwise in order to get just the information that you are looking for out of the register.

There is also the ability to communicate directly with the unit using TCP/IP Modbus protocol. These commands include reading coil status, reading holding registers, forcing single coils, diagnostic information, and presetting multiple registers. For more information on communications with the sensor without using an industry standard Modbus client, see the appendices at the end of the manual.

3.2.10 Power-Up Behavior

When the unit is powered up, it will immediately resume the mode that it was powered down in (either active or standby). If the sensor is in standby mode, the count, laser status, and flow status LEDs will be off, as well as the sample pump and laser. The particle counting will be stopped as well.

The power LED does remain on as long as there is power to the unit. Flow measurements are still being taken as if the unit were in active mode, so if the unit is queried for data while in standby mode the flow value returned will be zero. The sentinel count will be valid and continue to increment as usual. However, all the interval, sample, and rolling counts will be –1. The sample counter, interval counter, and the applicable status register bits will all be zero.

When the unit is activated and queried for data before the first sample has completed, the sample counts on both channels will be –1. The sample counter will be zero. The rolling counts and interval counts initially begin active mode with values of -1 until the end of the first interval, and then update at the end of each interval (nominally 1 or 35.3 seconds, depending on selected sample volume).

The sample status register bits will be zeros, while the interval status register bits will reflect the previous interval's status. The current status register bits indicate the immediate status, and update 4 times per second. The average flow value will be zero until the time it takes to complete 1 sample has elapsed. After that, it will be the average value of the flow for the entire previous sample period.

If the particle counter was active immediately before the power went off, it will resume sampling in the Active Mode when the power is restored. The Sample Counter and the Sentinel Counter will be cleared to zero, and will begin incrementing. The Forced Registers will no longer be used, and the Temporary Cubic Foot Mode will be cancelled.

3.3 EXTERNAL EXHAUST

The CI-3100-21 has a filtered external exhaust from the unit. The exhaust port on the rear panel of the unit is connected to an internal filter that collects the sampled particles and any particles generated by the sampling system.

There is an optional external exhaust tube fitting (Climet Part Number #01177800) that can be installed so that the exhaust from the unit can be ported away from the unit or into an air return system. The tubing adapter is installed by unscrewing the exhaust hood from the rear panel and screwing in the tube fitting in its place.

3.4 VISUAL INDICATORS (Front)

The CI-3100-21 provides five LED indicators on the front of the unit: *Power, Alarm, Count, Laser Status, and Flow Status*.

The *POWER LED* (green) illuminates when the power is turned on.

The *ALARM LED* (red) illuminates if the flow or laser LED is off for 2 consecutive seconds, and will remain on until both the laser and flow measurements are back within their nominal range.

The *COUNT LED* (yellow) flashes with every occurrence of a particle, up to ten counts per second. Higher concentrations will not flash any faster.

The *FLOW STATUS* (green) LED is illuminated when there is flow through the sensor, measured with a mass flow sensor, and the flow rate is within ± 10% of nominal.

The *LASER STATUS* (green) LED is illuminated when the power level of the laser diode is within the factory set level ± 10%. Both the flow and laser values are monitored 4 times per second, so their LEDs indicate in real time the flow and laser status.

3.5 VISUAL INDICATORS (Rear)

The CI-3100-21 provides two small LED indicators on the rear of the unit. These indicators are on the Ethernet Communications module. A green LED will be on solid when the unit has just been turned on or when the Ethernet module is rebooting.

The green LED will be flashing when there is network traffic in and out of the sensor. An amber / orange LED will be on when the Ethernet module senses a connection to an external network.

4 SETUP AND INSTALLATION

4.1 CONNECTING POWER AND ETHERNET COMMUNICATIONS

Power is supplied to the unit using the 3-conductor power cord included with the unit. One end of the cord has a female plug that attaches to the power entry module located on the unit's rear panel. The cord's other end has the familiar 3-prong male connector that plugs into a standard AC outlet.

The Ethernet™ connection between the remote sensor and the reporting software requires a CAT5 patch cable. The unit can communicate at either 10 Mbps or 100 Mbps. This communications cable is not provided with the unit. The cable length for each sensor location should be selected to allow room for sensor service, but without excessive cable clutter.

Figure 2 - CI-3100-21 Rear View below shows the rear panel. The power entry module is on the left, and the Ethernet™ jack is in the lower right corner. Above the jack is the MAC address label. The figure below also shows a long label that is included with the remote sensor to write the IP address for the sensor. This IP address must be different for each unit and must not conflict with any other computer address on the network. Ask your IT department for addresses for your remote sensors.

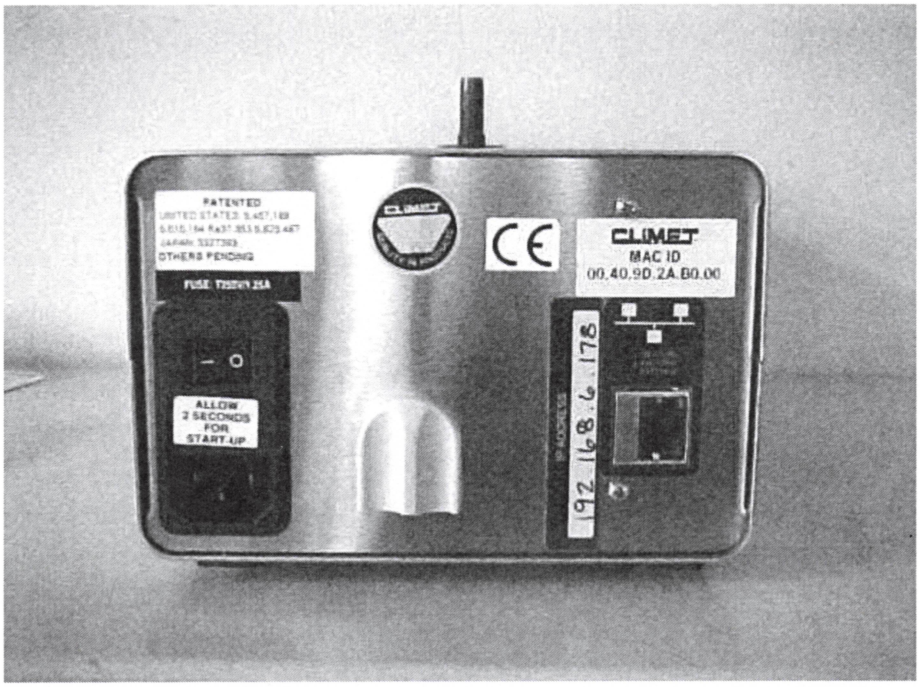


Figure 2 - CI-3100-21 Rear View

4.2 SETTING ADDRESS OF UNIT

NOTE: Every unit shipped from the factory will be set to a default initial IP Address of 192.168.50.1. This address will need to be changed to the correct address for the unit's assigned location, or set to acquire the IP Address from

the network. To do this, you will need to use the configuration utility program described below.

Since all new units start out with the same address, only one such unit may be connected to the network at a time. If fixed addresses are required, obtain from your IT department a list of IP addresses they want you to use for these particle counters. If your IT department tells you that the data ports you will be using with the particle counters will assign "fixed" addresses automatically, you can configure the particle counters accordingly. In this case, it is quite likely that your IT department is going to require a list of the MAC.

4.2.1 The Address Setting Utility

To set unit's address the unit must be powered on and connected to the Ethernet™ network. The unit will take about 30 seconds to boot and answer to an address query. Run the address setting utility program *CI3100-21_Configure.EXE* (installed from a CD included with the unit) on any computer connected to the network and on the same network segment as the unit. It is suggested that a private network be set up or use a cross-over cable between a dedicated computer network port and the unit to be addressed, so that multiple units already connected to the network are not listed in the device list.

4.2.2 Setting the IP Address

The program's first screen will appear as follows:

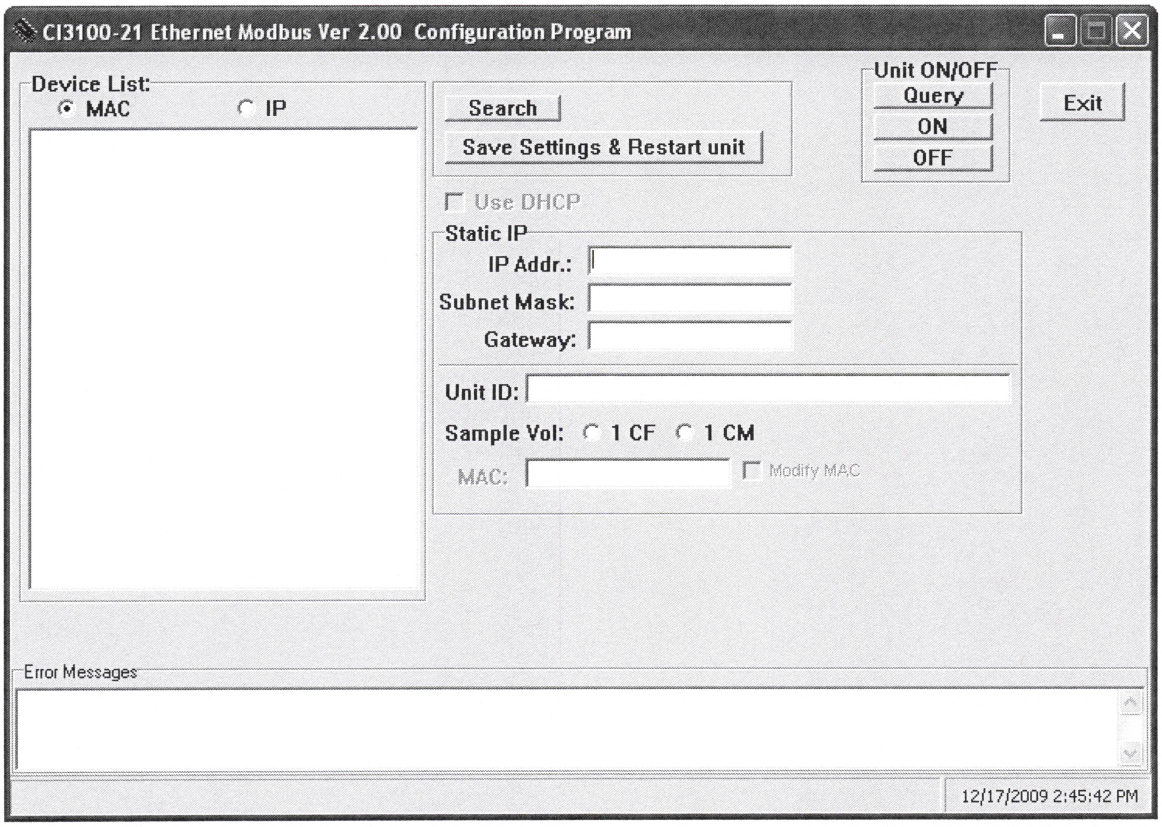
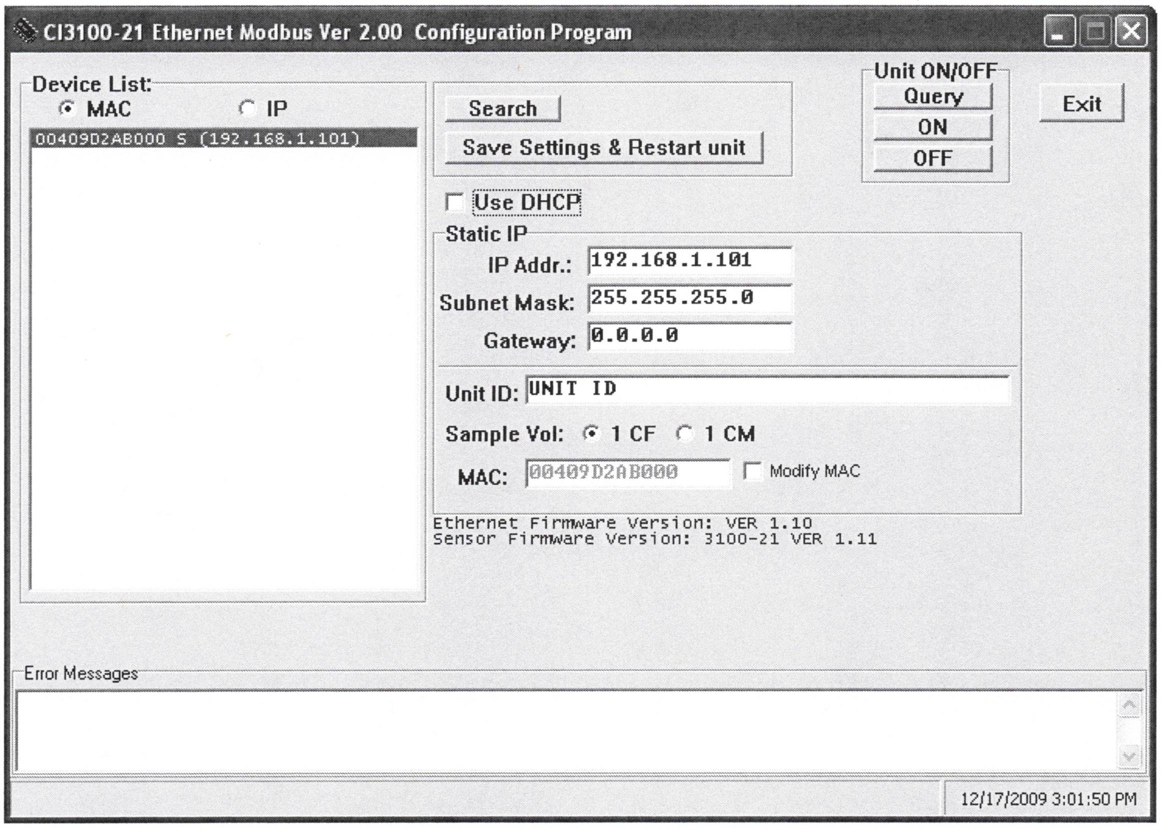


Figure 3 - Ethernet Modbus Configuration Program

Click on the *Search* button. The program will then build a list of MAC ID addresses (plus their associated IP addresses in parenthesis) on the left side of the window of all Ethernet CI-3100 units connected to the network. Between the MAC address and the IP address will be a letter *S* or *D*. An *S* means that the unit is in Static IP address mode. A *D* means that the unit is in DCHP mode and will obtain an IP address from the network. When the program finishes building the list, click on the MAC ID address that matches the MAC ID address label located just above the Ethernet™ port on the unit's rear panel. When the address is selected, the IP address parameters will be filled into the fields in the Static IP section of the window. Edit the IP address, subnet mask, and gateway numbers (in the middle of the window) to match those assigned to the unit by your network administrator. Also select the desired *sample volume* and give the unit the desired *unit ID* name.


CI3100-21 Ethernet Modbus Ver 2.00 Configuration Program
Device List:
Search
Save Settings & Restart unit
Unit ON/OFF
Query
ON
OFF
Exit
Error Messages

● MAC ○ IP

00409D2AB000 S (192.168.1.101)

☐ Use DHCP

Static IP

IP Addr.: 192.168.1.101

Subnet Mask: 255.255.255.0

Gateway: 0.0.0.0

Unit ID: UNIT ID

Sample Vol: ● 1 CF ○ 1 CM

MAC: 00409D2AB000 ☐ Modify MAC

```
Ethernet Firmware Version: VER 1.10
Sensor Firmware Version: 3100-21 VER 1.11
```

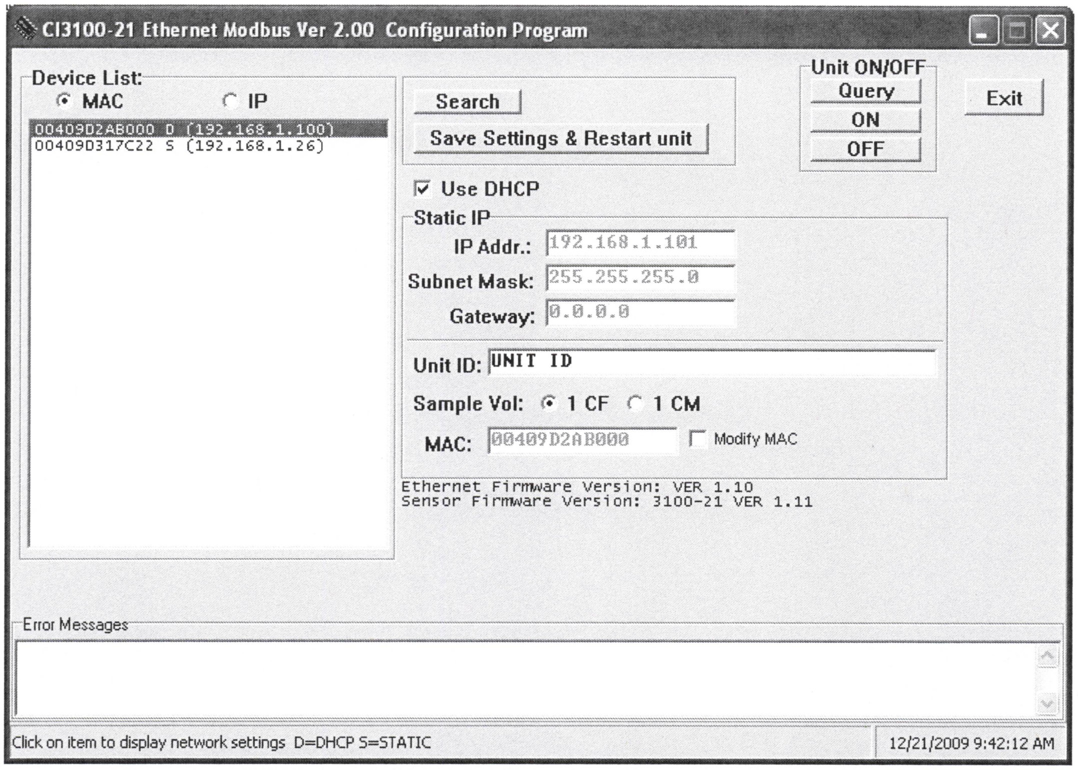
12/17/2009 3:01:50 PM

Figure 4 - Ethernet Modbus Configuration Program

4.2.3 Setting DHCP Addressing

By using Dynamic Host Configuration Protocol (DHCP), the network will set the IP Address of the unit. The unit will need to be configured as a DHCP Client (Available in DIGI firmware version 1.10 and above). This makes swapping out particle counters for calibration or service very easy since the IP Address remains constant for the data port, and any particle counter plugged into that port will obtain the proper IP address whenever it is powered on.

While this feature is quite attractive to us as users, it can be a security problem for the IT department. Letting the IT department know what the MAC Addresses are for the particle counters that will be connecting to the network can help them resolve those security concerns.



CI3100-21 Ethernet Modbus Ver 2.00 Configuration Program
Device List:
Search
Save Settings & Restart unit
Unit ON/OFF
Query
ON
OFF
Exit
Error Messages

● MAC ○ IP

```
00409D2AB000 D (192.168.1.100)
00409D317C22 S (192.168.1.26)
```

☑ Use DHCP

Static IP

IP Addr.: 192.168.1.101

Subnet Mask: 255.255.255.0

Gateway: 0.0.0.0

Unit ID: UNIT ID

Sample Vol: ● 1 CF ○ 1 CM

MAC: 00409D2AB000 ☐ Modify MAC

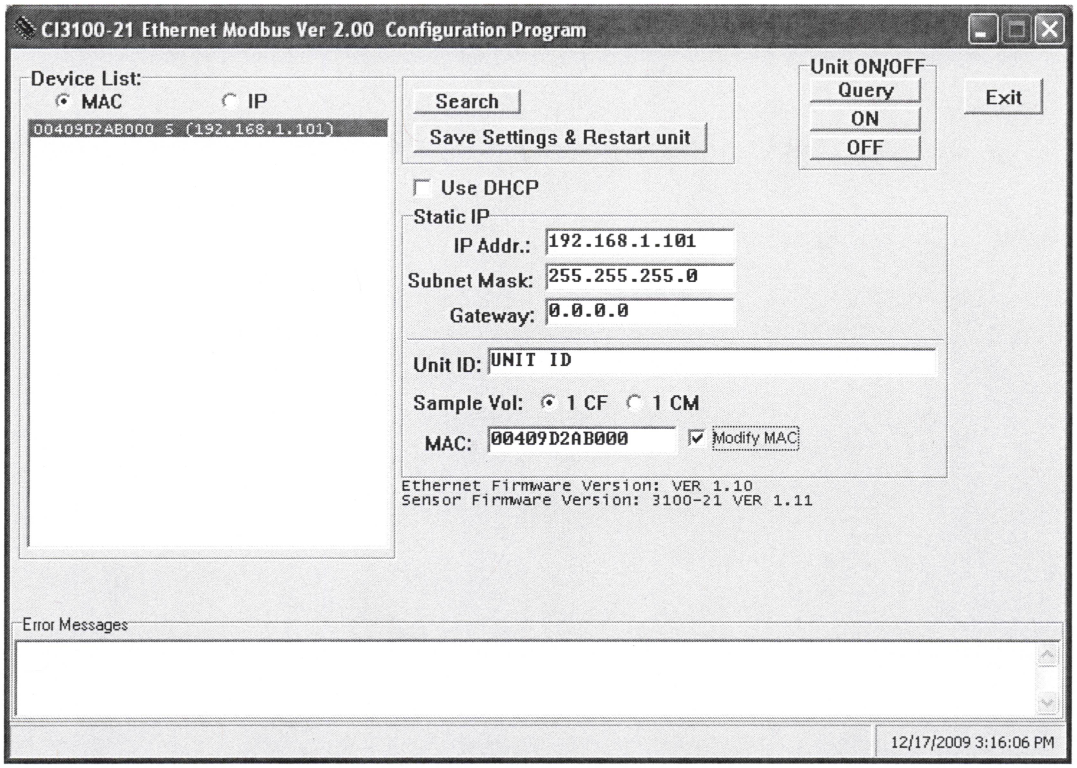
```
Ethernet Firmware Version: VER 1.10
Sensor Firmware Version: 3100-21 VER 1.11
```

Click on item to display network settings D=DHCP S=STATIC

12/21/2009 9:42:12 AM

4.2.4 *Changing the MAC Address*

It may be necessary to change the MAC Address for a particle counter for some reason. Perhaps the most likely reason for doing so would be that the IP interface module failed for some reason, and the replacement part simply needs to be reconfigured to have the original MAC Address so that the IT department will allow it to connect to the network with minimal hassle.


CI3100-21 Ethernet Modbus Ver 2.00 Configuration Program
Search
Save Settings & Restart unit
Unit ON/OFF
Query
ON
OFF
Exit
Error Messages

Device List: ● MAC ○ IP

00409D2AB000 S (192.168.1.101)

☐ Use DHCP

Static IP

IP Addr.: 192.168.1.101

Subnet Mask: 255.255.255.0

Gateway: 0.0.0.0

Unit ID: UNIT ID

Sample Vol: ● 1 CF ○ 1 CM

MAC: 00409D2AB000 ☑ Modify MAC

```
Ethernet Firmware Version: VER 1.10
Sensor Firmware Version: 3100-21 VER 1.11
```

12/17/2009 3:16:06 PM

The utility program allows MAC Address to be modified as well. Click in the Modify MAC box. A warning message will pop up stating that MAC address's need to be unique within the local network. Click OK and set the new MAC address. Use the Save Settings & Restart unit button to complete the changes and reboot the unit. Use the Search button to locate the unit after rebooting(about 2 minutes). Confirm that the new settings are correct. The unit is now ready to be used with the new MAC Address.

4.2.5 Saving the Settings

Clicking on the *Save Settings & Restart unit* button and also on the subsequent warning screens will store the new settings into the unit. Allow the sensor to reboot (wait at least 2 minutes for the unit to reboot). During this time DO NOT TURN THE UNIT'S POWER OFF. After the 2 minutes, confirm the edited network settings are correct by clicking again on the *Search* button and verifying the IP address, subnet mask, and gateway numbers match what was submitted to the specific MAC ID address of the unit being programmed.

4.2.6 Checking the Settings

With the network settings correct, click on the *Query* button. The unit should respond, which will cause a small pop up window to appear. It will indicate the unit is either on or off. Click on the OK button to eliminate the pop up window. Click on the ON button under the Query button to turn on the sensor for the next section of testing. Click on the *Exit* button to leave the program after all of the CI-3100-21 units have been addressed.

4.2.7 Apply the Label

Locate the IP Address label and clear cover label that came with the unit. Write the newly programmed IP Address on the label and attach the label to the remote sensor. Figure 2 - CI-3100-21 Rear View shows a suggested location for this label. This label can also be attached to the front or top of the unit so that operators in the rooms can read the information without turning the unit around to view the rear panel. Place the clear cover label over the top of the IP Address label to protect the information on the label from being damaged. Additional labels can be ordered from Climet using part number 01241900.

4.3 VIEWING DATA FROM THE UNIT

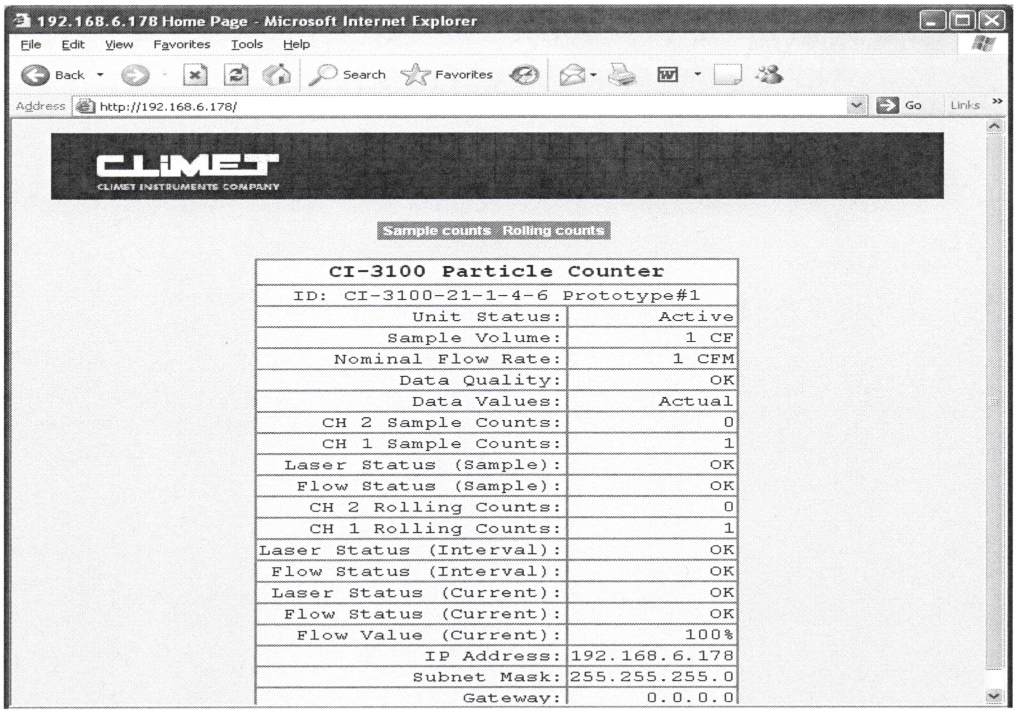
Sample data from the unit can be viewed in two ways using any computer connected to the network. The simplest method uses the web browser of the computer, while the other method requires running a program on the computer designed to send and receive data using the TCP/IP Modbus protocol.

Web Pages available in the unit:

http://IP_address/
http://IP_address/rolling.htm
http://IP_address/sample.htm
http://IP_address/sampledatap1.htm
http://IP_address/info.htm

To use the web browser method, simply start the computer's web browser program and click on the address bar containing the web address. Edit the existing address to just http:// plus the unit's IP address, and then press <Enter>. For example, if the unit's IP address is 192.168.6.178, one would edit the address to http://192.168.6.178 and then press <Enter>. The web page shown in Figure 5 - CI-3100 Web Page would appear on the computer screen.

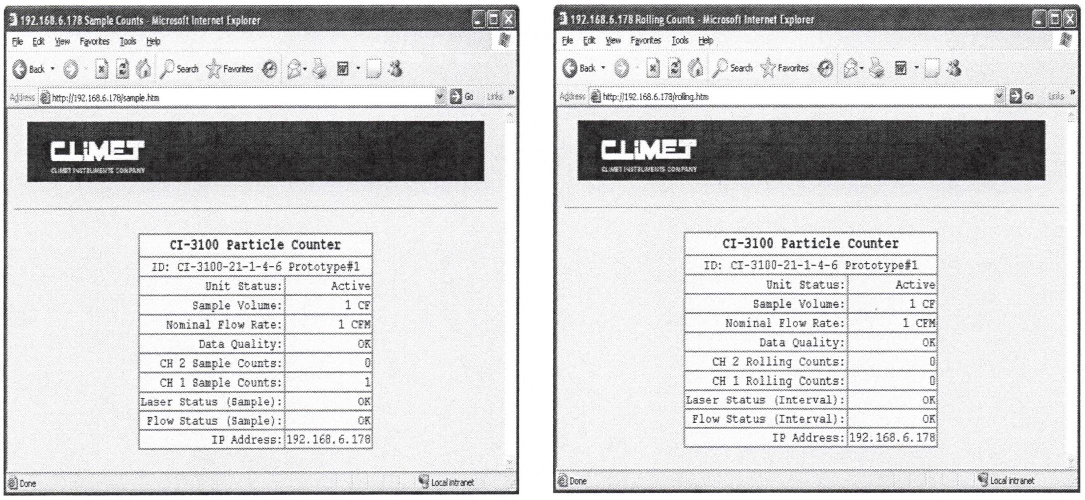
This page updates every 30 seconds showing you the most recent sample counts, sample status, rolling counts, interval status, current status, and current flow values. This page also provides the unit ID string, current unit status, selected sample volume, the data quality, and whether the values are actual values or forced values.


192.168.6.178 Home Page - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back
Search
Favorites
Address http://192.168.6.178/
Go
Links
CLIMET
CLIMET INSTRUMENTS COMPANY
Sample counts Rolling counts

CI-3100 Particle Counter	
ID: CI-3100-21-1-4-6 Prototype#1	
Unit Status:	Active
Sample Volume:	1 CF
Nominal Flow Rate:	1 CFM
Data Quality:	OK
Data Values:	Actual
CH 2 Sample Counts:	0
CH 1 Sample Counts:	1
Laser Status (Sample):	OK
Flow Status (Sample):	OK
CH 2 Rolling Counts:	0
CH 1 Rolling Counts:	1
Laser Status (Interval):	OK
Flow Status (Interval):	OK
Laser Status (Current):	OK
Flow Status (Current):	OK
Flow Value (Current):	100%
IP Address:	192.168.6.178
Subnet Mask:	255.255.255.0
Gateway:	0.0.0.0

Figure 5 - CI-3100 Web Page

By clicking on the 'Sample Counts' or 'Rolling Counts' links at the top of the main page, subsets of data can be displayed of just the sample counts or just the rolling counts. These screens are displayed below.

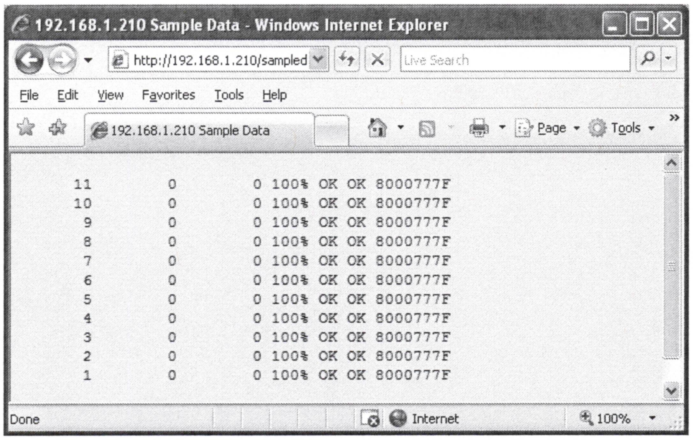

192.168.6.178 Sample Counts - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back
Search
Favorites
Address http://192.168.6.178/sample.htm
Go
Links
CLIMET
CLIMET INSTRUMENTS COMPANY
Done
Local intranet
192.168.6.178 Rolling Counts - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back
Search
Favorites
Address http://192.168.6.178/rolling.htm
Go
Links
CLIMET
CLIMET INSTRUMENTS COMPANY
Done
Local intranet

CI-3100 Particle Counter	
ID: CI-3100-21-1-4-6 Prototype#1	
Unit Status:	Active
Sample Volume:	1 CF
Nominal Flow Rate:	1 CFM
Data Quality:	OK
CH 2 Sample Counts:	0
CH 1 Sample Counts:	1
Laser Status (Sample):	OK
Flow Status (Sample):	OK
IP Address:	192.168.6.178

CI-3100 Particle Counter	
ID: CI-3100-21-1-4-6 Prototype#1	
Unit Status:	Active
Sample Volume:	1 CF
Nominal Flow Rate:	1 CFM
Data Quality:	OK
CH 2 Rolling Counts:	0
CH 1 Rolling Counts:	0
Laser Status (Interval):	OK
Flow Status (Interval):	OK
IP Address:	192.168.6.178

Figure 6 - Sample Counts and Rolling Counts

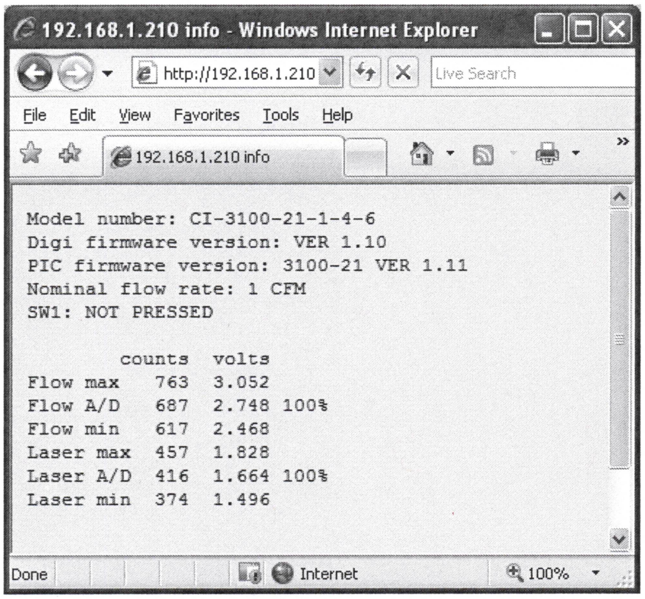
The *sampledatap1.htm* web page provides a history of the last 1440 completed samples. This would 24 hours of data in CF sample mode.


192.168.1.210 Sample Data - Windows Internet Explorer
http://192.168.1.210/sampled
Live Search
File Edit View Favorites Tools Help
192.168.1.210 Sample Data
Page
Tools
Done
Internet
100%

```
    11         0         0 100% OK OK 8000777F
    10         0         0 100% OK OK 8000777F
     9         0         0 100% OK OK 8000777F
     8         0         0 100% OK OK 8000777F
     7         0         0 100% OK OK 8000777F
     6         0         0 100% OK OK 8000777F
     5         0         0 100% OK OK 8000777F
     4         0         0 100% OK OK 8000777F
     3         0         0 100% OK OK 8000777F
     2         0         0 100% OK OK 8000777F
     1         0         0 100% OK OK 8000777F
```

Figure 7 – Sample Data web page

The *info.htm* web page provides firmware versions for both Processors in the CI-3100-21. Also the current and calibrated flow and LASER status information is provided.


192.168.1.210 info - Windows Internet Explorer
http://192.168.1.210
Live Search
File Edit View Favorites Tools Help
192.168.1.210 info
Done
Internet
100%

```
Model number: CI-3100-21-1-4-6
Digi firmware version: VER 1.10
PIC firmware version: 3100-21 VER 1.11
Nominal flow rate: 1 CFM
SW1: NOT PRESSED

        counts  volts
Flow max   763  3.052
Flow A/D   687  2.748 100%
Flow min   617  2.468
Laser max  457  1.828
Laser A/D  416  1.664 100%
Laser min  374  1.496
```

Figure 8 – Information web page

Using the program method, all Ethernet Modbus™ registers and coils are available at all times, and the retrieved data can be displayed and logged according to the abilities of the program. Commercially available software exists which uses the Ethernet Modbus™ over TCP/IP protocol, besides custom software one can generate. See the appendices for the TCP/IP and Modbus Protocol command lists.

5 TROUBLESHOOTING and TESTING

5.1 FORCING VALUES

The forced value feature is provided for the purpose of facilitating validation of monitoring system software. Forced values will be returned by the sensor and may be used to validate displays, alarms and reports of the monitoring system.

To verify that the monitoring system software is working properly, each unit may be sent forced data by writing data into the addresses of the forced holding registers from the data acquisition software package. The program will need to set the coil for forced counts to have the forced counts appear in the actual holding registers. The two data sets, actual and forced, will match when in Forced Data Mode. Remember that bit 31 of the status registers will always return to the acquisition program a value of 1 if the data is in the forced mode.

NOTE: The Forced Holding Registers are strictly static registers that can be changed only through writing data to them using the Write Data command. One of the results of this fact is that normally incrementing registers, such as the Sentinel Counter or the Interval Counter, do not increment. If your monitoring software tracks these counters to detect communication failures, these registers will need considerable attention.

While the register names might indicate some kind of logic is associated with them, it is entirely possible to force completely irrational values into the actual holding registers by writing those values to the corresponding forced holding registers. For example, it is quite possible to write values into the unused bits of the Status Register, or to write values to the Status Register that would never occur in "nature", or to write negative values into other registers.

CLiMET Instruments has a software program known as the Validation Utility that provides seamless control of the forced holding registers to assist in system validation. This software makes the process of using the forced holding registers much easier to use, allowing the users to validate the installation of one or more sensors in conjunction with the Particle Counting Software of choice.

5.2 LASER AND FLOW STATUS

There are two ways to determine laser and flow status (assuming the unit is in active mode): by observing the flow and laser LEDs on the front panel of the unit, or by triggering events in the data acquisition software based on the quality, laser, and/or flow bit values of the status registers for each sensor. If the bit values are high (or true) then the status is good and sampling continues. If a bit value is low (or false) then the sensor needs to be looked at to see why the status is bad. Both the LEDs and the status bits adhere to the same standards of describing laser and flow levels as acceptable (nominal flow ± 10%, nominal laser power ±10%).

Bad flow or laser status that occurs during a sample will be latched in the status bits for that completed interval and sample. Bad laser or flow status will be latched if it persists for 2 seconds.

The sensor status information is located in the lower register of the 32 bit status register. The table below shows various status bit positions in the register. This is a right to left configuration, which is most familiar to programmers, with bit 31 being the most significant bit (MSB) and bit 0 being the least significant bit (LSB).

Contents	Sample status	Interval status	Current status
Quality (1=good, 0=bad)	Bit 14	Bit 10	Bit 6
Flow (1=good, 0=bad)	Bit 13	Bit 9	Bit 5
Laser(1=good, 0=bad)	Bit 12	Bit 8	Bit 4

Table 1 - Status Bits

If the laser or flow status was bad during the sample or interval, the quality bit will also be bad. This allows the user to trigger on the quality bit to start events within the software program rather than having to watch both the laser bit and the flow bit. The current quality status reacts the same way but does not stay bad in the status register when the status condition corrects itself.

Bit 3 of the status registers is the sampling bit. This bit is high when the unit is running and collecting counts with both the laser and flow status in good condition. This bit goes low when either the laser or flow status goes bad. While the status is bad, the sensor stops collecting counts and stops incrementing the interval counter.

See Chapters 7-9 for more detailed information about the status registers.

6 HOLDING REGISTER and COIL ADDRESSES

6.1 Count Data and Unit status Registers

The address of the holding registers based on the 5-digit Generic PLC are as follows:

Holding Registers		Data Contents
40001 (upper)	40002 (lower)	Rolling fine counts
40003 (upper)	40004 (lower)	Rolling coarse counts
40005 (upper)	40006 (lower)	Status word
40007 (upper)	40008 (lower)	Average Sample flow
40009 (upper)	40010 (lower)	Sample counter
40011 (upper)	40012 (lower)	Sentinel counter
40013 (upper)	40014 (lower)	Sample fine counts
40015 (upper)	40016 (lower)	Sample coarse counts
40017 (upper)	40018 (lower)	Interval Counter
40019 (upper)	40020 (lower)	Current Flow
40021 (upper)	40022 (lower)	Average Interval Flow
40023 (upper)	40024 (lower)	Interval fine counts
40025 (upper)	40026 (lower)	Interval coarse counts
40027 (upper)	40028 (lower)	Forced Rolling fine counts
40029 (upper)	40030 (lower)	Forced Rolling coarse counts
40031 (upper)	40032 (lower)	Forced Status word
40033 (upper)	40034 (lower)	Forced Average sample flow
40035 (upper)	40036 (lower)	Forced Sample counter
40037 (upper)	40038 (lower)	Forced Sentinel counter
40039 (upper)	40040 (lower)	Forced Sample fine counts
40041 (upper)	40042 (lower)	Forced Sample coarse counts
40043 (upper)	40044 (lower)	Forced Interval Counter
40045 (upper)	40046 (lower)	Forced Current Flow
40047 (upper)	40048 (lower)	Forced Average Interval Flow
40049 (upper)	40050 (lower)	Forced Interval fine counts
40051 (upper)	40052 (lower)	Forced Interval coarse counts

Table 2 - Enumerated Modbus Registers (Outputs)

6.2 Unit ID Holding Registers

Address	Data Format	Unit ID Array Indexing
40100	ASCII Bytes (Hi, Low)	Unit ID[2], Unit ID[1]
40101	ASCII Bytes (Hi, Low)	Unit ID[4], Unit ID[3]
40102	ASCII Bytes (Hi, Low)	Unit ID[6], Unit ID[5]
40103	ASCII Bytes (Hi, Low)	Unit ID[8], Unit ID[7]
40104	ASCII Bytes (Hi, Low)	Unit ID[10],Unit ID[9]
40105	ASCII Bytes (Hi, Low)	Unit ID[12],Unit ID[11]
40106	ASCII Bytes (Hi, Low)	Unit ID[14],Unit ID[13]
40107	ASCII Bytes (Hi, Low)	Unit ID[16],Unit ID[15]
40108	ASCII Bytes (Hi, Low)	Unit ID[18],Unit ID[17]
40109	ASCII Bytes (Hi, Low)	Unit ID[20],Unit ID[19]
40110	ASCII Bytes (Hi, Low)	Unit ID[22],Unit ID[21]
40111	ASCII Bytes (Hi, Low)	Unit ID[24],Unit ID[23]
40112	ASCII Bytes (Hi, Low)	Unit ID[26],Unit ID[25]
40113	ASCII Bytes (Hi, Low)	Unit ID[28],Unit ID[27]
40114	ASCII Bytes (Hi, Low)	Unit ID[30],Unit ID[29]
40115	ASCII Bytes (Hi, Low)	Unit ID[32],Unit ID[31]

Table 3 - Holding Registers for Unit ID

6.3 Coil Addresses

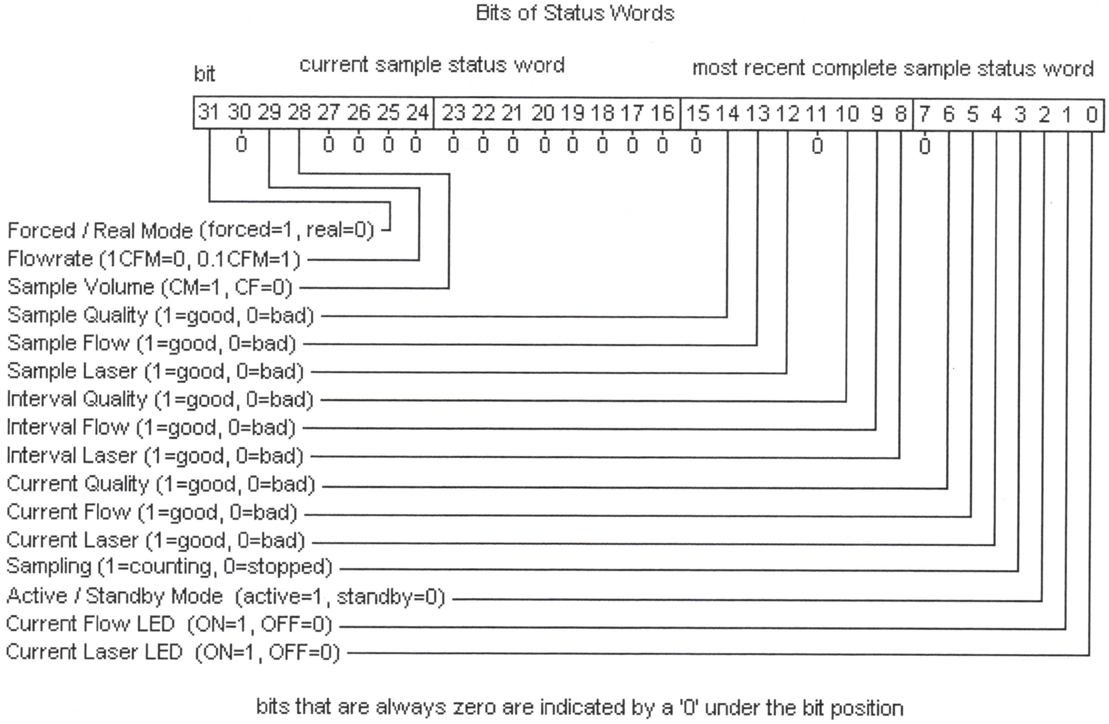
The address of the data coils based on the 5-digit Generic PLC are as follows:

Coils	Data Contents (value to write to coil)
1 (upper)	Standby (0000) / Active Mode (FF00)
2 (upper)	Real Data Mode (0000) / Forced Data Mode (FF00)
3 (upper)	Temporary cubic foot mode (FF00)

Table 3 - Enumerated Modbus Coils (Inputs)

The Status Registers are configured as described below.

Figure 7 - The Status Register Bitmap


Bits of Status Words
bit
current sample status word
most recent complete sample status word
31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Forced / Real Mode (forced=1, real=0)
Flowrate (1CFM=0, 0.1CFM=1)
Sample Volume (CM=1, CF=0)
Sample Quality (1=good, 0=bad)
Sample Flow (1=good, 0=bad)
Sample Laser (1=good, 0=bad)
Interval Quality (1=good, 0=bad)
Interval Flow (1=good, 0=bad)
Interval Laser (1=good, 0=bad)
Current Quality (1=good, 0=bad)
Current Flow (1=good, 0=bad)
Current Laser (1=good, 0=bad)
Sampling (1=counting, 0=stopped)
Active / Standby Mode (active=1, standby=0)
Current Flow LED (ON=1, OFF=0)
Current Laser LED (ON=1, OFF=0)
bits that are always zero are indicated by a '0' under the bit position

NOTE: The sample above models the bits from Least Significant Bit (bit 0) to Most Significant Bit (bit 31). This is a right to left configuration which most programmers use. Some Modbus PLC item names model the bits of the registers as left to right configuration with the MSB as bit 1(not 0) and the LSB as bit 32 of a double register. This is important to remember when specifying bits from the status registers.

7 RECOMMENDED REGISTER USAGE

Below are recommended Holding Registers to use for different configurations of the CI-3100-21.

NOTE: The bits listed below are in the right to left configuration. Check with your Modbus driver to see if this convention is used. The left to right configuration is also listed with the bit numbering adjusted from 1 to 32 rather than 31 to 0.

7.1 CUBIC FOOT OR CUBIC METER

Choosing the sample size simply sets the length of time the particle counter uses to accumulate a complete sample. Since air moves through the particle counter at the nominal rate of 1 cubic foot per minute, a sample will be completed in 1 minute in the Cubic Foot Mode, or 35.3 minutes the Cubic Meter Mode. This also means that the intervals (the length of time between each set of intermediate calculations) will be 1 second and 35.3 seconds, respectively. (Each interval is 1/60th of a sample.)

7.2 Minimal Register Configuration

These data registers will give the sample counts for both particle sizes and the current status bits from the status register. This usage corresponds to the traditional particle counter that can only display the data obtained at the end of the most recently completed sample.

Ch. 1 sample data	40013 L (L denotes Long register or double register)
Ch. 2 sample data	40015 L
Current sensor status	40006:6 (Quality) 40006:5 (Flow) 40006:4 (Laser)
(left to right config.)	40006:26 (Quality) 40006:27 (Flow) 40006:28 (Laser)

(bits will be high if condition is good, low if condition is bad)

7.3 Nominal Register Configuration

These data registers will give the rolling and sample counts for both particle sizes, status register, average sample flow, and the current status bits from the status register. Use the Sample Data if the traditional particle counter behavior is desired, or use the Rolling Data if the most recently available data is desired.

Rolling Data is identical to the Sample Data at the conclusion of each Sample Interval, but is continuously calculated throughout sampling so that it contains the most recently counted data for the sampling interval. The data is updated every interval for the Rolling Data Registers. This is of limited importance in the Cubic Foot Mode, but can be very convenient in Cubic Meter Mode.

Ch. 1 rolling data	40001 L (L denotes Long register or double register)
Ch. 2 rolling data	40003 L
Ch. 1 sample data	40013 L
Ch. 2 sample data	40015 L
Status register	40005 L
Average sample flow	40007 L
Current sensor status	40006:6 (Quality) 40006:5 (Flow) 40006:4 (Laser)
(left to right config.)	40006:26 (Quality) 40006:27 (Flow) 40006:28 (Laser)

(bits will be high if condition is good, low if condition is bad)

7.4 Maximum Register Configuration

All of the holding registers and their addresses are listed in the previous chapter. These include registers for sample count data plus sensor status, various counters, and additional flow readings. If your requirements include immediate notification of sensor problems, including network problems, this is the configuration you will need to use with your Facility Monitoring Software.

In addition to the Sample Data, Rolling Data, and Status bits, the Interval Data can be accessed to provide "live" information about the progress on the current Sample. Another register that is available is the Sentinel Counter, which can be used to verify that the particle counter is working and communicating correctly.

CLiMET Instruments' DataPro3 uses this configuration to communicate with these sensors. This allows the sensors to be used with the maximum assurance that they are working and communicating correctly, and provides unmistakable notification of any problems within a few seconds of occurrence.

7.5 Reading Unit ID by Holding Register Access

The CI-3100-21 Ethernet OPT provides access to the Unit ID through Holding Register access (in Digi firmware version 1.10 and above). Table 3 provides the addressing and byte ordering format. The Starting address is 40100 and ending address is 40115, providing 16 Registers(32 ASCII characters) for the Unit ID.

Register Format: Each register contains two ASCII characters. The low byte contains the first character while the high byte contains the second character.

Example Usage reading Unit ID:

Example Unit ID: CI-3100-21-x-4-6
Issue a Multiple Register read command starting at Address 40100 for 16 registers. This will return the all 32 characters of the Unit ID.

Holding Register Contents: 40100 = IC
40101 = 3-
40102 = 01
40103 = -0
40104 = 21
40105 = -x
40106 = 4-
40107 = 6-
40108 =

All un-used characters a space character returned. This space character is added to fill the Unit ID to a full 32 characters when the configuration utility writes the Unit ID.

To Set the Unit ID, see section 4.2 of this User Manual.

8 Modbus TCP/IP AVAILABLE COMMANDS

NOTE: All TCP/IP commands sent to the unit must be preceded by a MBAP header packet. Sometimes the Modbus server takes care of this feature so that the operator does not have to. The available commands are summarized as follows:

- SET UNIT TO ACTIVE / STANDBY MODE (pump off)
- SET DATA MODE TO REAL / FORCED
- SET SAMPLE VOLUME TO 1 CUBIC FOOT
- READ ACTIVE / STANDBY SETTING AND REAL/FORCED DATA MODE SETTING
- READ REAL AND/OR FORCED COUNTS + STATUS + FLOW + COUNTERS
- SEND FORCED DATA
- ECHO BACK A 16 BYTE TEST ARRAY (A DIAGNOSTIC FUNCTION)
- CLEAR COUNTERS AND RESET SAMPLE TIMER

All commands share a common format at the beginning of their command string. The first byte must always take on the hex value 01. The second byte is always the "function". The function values (in hex) supported by the CI-3100-21 are 01, 03, 05, 08, and 10. Their Modbus definitions are as follows:

Function Hex Value	Definition
01	read coil status
03	read holding registers
05	force single coil
08	diagnostics
10	preset multiple registers

Table 4 - The Modbus Command Set

Listed below are the necessary bytes for each command which must follow the 01 byte (in hex) and function byte (in hex) to form the complete command string. Examples of complete command strings are included.

8.1 SET UNIT TO ACTIVE / STANDBY MODE

A 2 byte coil address of 00 01 followed by a 2 byte value of FF 00 (for active) or 00 00 (for standby).

Example: set to active: 01 05 00 01 FF 00
Example: set to standby: 01 05 00 01 00 00

Note that the first byte of the command string, 01, must be in hexadecimal format. This is true for all command strings. When the active mode command is received the CI-3100-21 immediately begins functioning, acquiring data and refreshing rolling data memory every update period, and sample data memory every sample period.

Upon receiving the command, the unit will send back the exact same command string.

8.2 SET DATA MODE TO REAL / FORCED

A 2 byte coil address of 00 02 followed by a 2 byte value of 00 00 (for real acquired data sent as real data) or FF 00 (for artificial data residing in memory and sent in place of the real data).

Example: set data mode to real: 01 05 00 02 00 00
Example: set data mode to forced: 01 05 00 02 FF 00

The forced value feature is provided for the purpose of facilitating validation of monitoring system software. Forced values will be returned by the sensor and may be used to validate displays, alarms and reports of the monitoring system.

Note that the artificial "forced" data must be sent to the CI-3100-21 for storage in the forced data registers at some point in time prior to seeing the same data output by the unit, in place of the real data, when running in forced data mode. See SEND FORCED DATA command below to send "forced" data to the unit. Upon receiving the command, the unit will send back the exact same command string.

8.3 SET SAMPLE VOLUME TO 1 CUBIC FOOT

NOTE: 0.1 CFM Models have sample volumes that are 0.1 CF and 0.1 CM.

A 2 byte coil address of 00 03 followed by a 2 byte value of FF 00.

Example: set sample volume to 1 ft.^{3}: 01 05 00 03 FF 00

This command would normally be used only on 1 m^3 sample volume units, for diagnostic purposes, to have count data available in 1 minute rather than 35.3 minutes. When power is cycled to the unit, or the unit is put in standby and then active mode with Modbus commands, the original sample volume in memory will automatically be restored to the unit.

Upon receiving the command, the unit will send back the exact same command string. If the unit's sample volume is currently 1 m^3 when it receives this command, the sample counter and sample timer are reset to zero. The rolling counts and buffers are zeroed, while the sample counts are set to -1. Nothing happens if the sample volume is already 1 ft^3.

8.4 READ ACTIVE/STANDBY OR REAL/FORCED DATA MODE

A 2 byte address for the first coil to read followed by a 2 byte value for the number of coils to read (must be 00 01). The first coil (address 00 01) represents the unit being active=1 or standby=0. The second coil (address 00 02) represents the unit forced count mode being on=1 or off=0. This command is limited to 1 coil read at a time. One can start at coil 1 and read that coil, or start at coil 2 and read that coil (this means active/standby and data mode must be read separately).

Example: read unit active/standby setting: 01 01 00 01 00 01
Example: read data mode setting of unit: 01 01 00 02 00 01

Upon receiving the command, the unit will send back the first 2 bytes of the command string, followed by a byte of value 01 (representing the byte count of data to follow, always 01), then a byte whose bits represent the status of the coil requested. The returned byte representing the status of the coil will have bit 0 representing the requested coil status (1=on, 0=off). All higher bits are padded with zeros.

8.5 READ REAL OR REAL+FORCED COUNTS AND STATUS

A 2 byte address for the beginning holding register to read (00 00 to 00 32), followed by a 2 byte hex value of the number of registers (not bytes) to read (2 (00 02H) for a single register pair, 26 (00 1AH) for all real register data, and up to 52 (00 34H) for both real and forced data registers). The following table shows the holding register addresses and what they contain. Each holding register is 16 bit (2 bytes). This command has slight variation. One must begin at the first holding register address the operator wants and then the number of registers to read. Note that counts per channel are stored in 2 16-bit registers.

Address (upper)	Address (lower)	Contents
0	1	Rolling fine counts registers
2	3	Rolling coarse counts registers
4	5	status registers
6	7	average sample flow registers
8	9	Sample counter registers
10	11	sentinel counter registers
12	13	Sample fine counts registers
14	15	Sample coarse counts registers
16	17	interval counter registers
18	19	Current flow registers
20	21	Average interval Flow registers
22	23	Interval fine counts registers
24	25	Interval coarse counts registers
26	27	Forced rolling fine counts registers
28	29	Forced rolling coarse counts registers
30	31	Forced status registers
32	33	Forced average sample flow registers
34	35	Forced sample counter registers
36	37	Forced sentinel counter registers
38	39	Forced sample fine counts registers
40	41	Forced sample coarse counts registers
42	43	Forced interval counter registers
44	45	Forced current flow registers
46	47	Forced average interval flow registers
48	49	Forced Interval fine counts registers
50	51	Forced Interval coarse counts registers

Table 5 - Modbus Registers (16-bit)

Example:
read real rolling counts, status, and avg. sample flow: 01 03 00 00 00 08

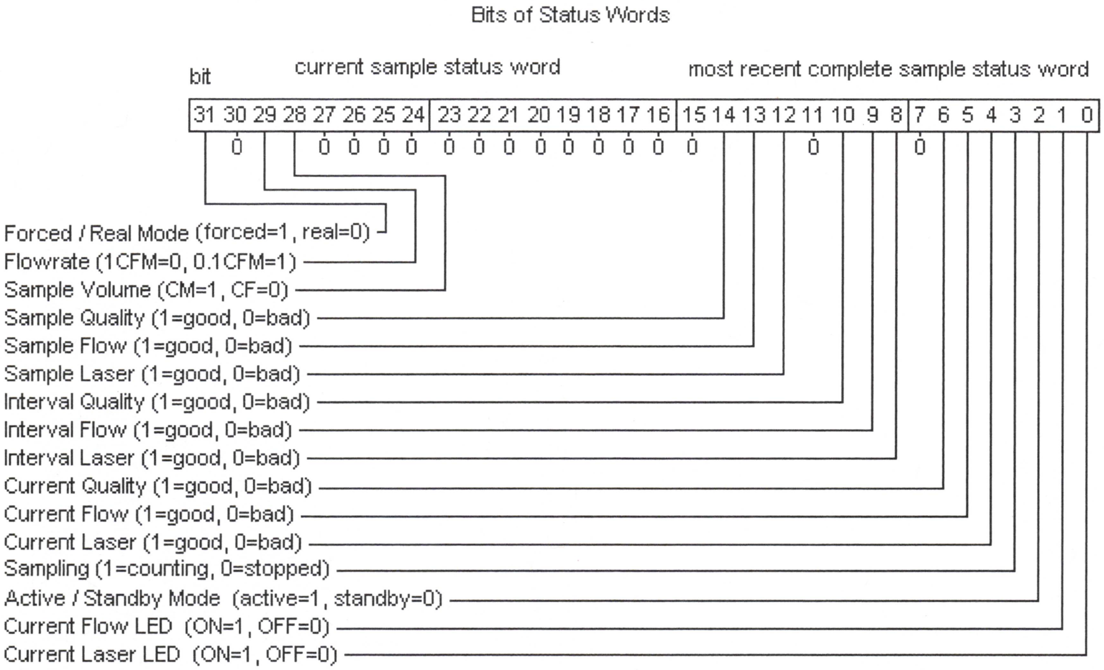
Example:
read all forced data: 01 03 00 1A 00 1A

The status registers (there are 2, containing bits 0 through 31) are formatted such that the status information for the current status, the interval status, and the sample status are in the same bit positions in different half-bytes (or nibbles) of the lower status register. The upper register has two information bits at positions 31 and 28. Bit 31 is the Forced / Real mode bit. If this bit is high then the data in the data holding registers is forced data. If the bit value is low then the data holding registers contain actual real information. Bit 28 indicates the sample volume mode that is programmed into the remote sensor. If the value is 1 then the sensor is in Cubic Meter mode. If the value is 0 then the sensor is in Cubic Foot mode.

The status bits in the lower register keep track of the Quality, Laser Power, and Flow Rate of the different time periods. The lower status register is split into four sections: the sample section, the interval section, the current section, and the sampling+mode+LED section. The first two sections are formatted the same. There is a quality bit, a flow bit, and a laser bit. These bits are a value of 1 (or true) when the quality, flow, and laser have been good during the previous time period (sample or interval). The third section is very similar to the first two but relates to what is happening with the sensor at this very moment. The fourth section has four bits with the following attributes:

- bit 3 (Sampling). This bit is high when the sensor is sampling and transferring counts into the memory of the sensor. This bit is low when the collection has stopped due to a status failure.
- bit 2 (Active / Standby Mode). This bit is high when the sensor is in active sampling mode and low when the unit is in Standby mode.
- bit 1 (Current Flow LED). This bit mirrors the Flow Status LED on the front panel of the remote sensor. If the LED is on, the bit will be high. If the LED is off, the bit will be low. This bit indicates the immediate flow status without the 2 second qualifier test for bad flow.
- bit 0 (Current Laser LED). This bit mirrors the Laser Status LED on the front panel of the remote sensor. It has the same response attributes as bit 1 above.

A pictorial of the status bits appears below.


Bits of Status Words
bit
current sample status word
most recent complete sample status word
31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Forced / Real Mode (forced=1, real=0)
Flowrate (1CFM=0, 0.1CFM=1)
Sample Volume (CM=1, CF=0)
Sample Quality (1=good, 0=bad)
Sample Flow (1=good, 0=bad)
Sample Laser (1=good, 0=bad)
Interval Quality (1=good, 0=bad)
Interval Flow (1=good, 0=bad)
Interval Laser (1=good, 0=bad)
Current Quality (1=good, 0=bad)
Current Flow (1=good, 0=bad)
Current Laser (1=good, 0=bad)
Sampling (1=counting, 0=stopped)
Active / Standby Mode (active=1, standby=0)
Current Flow LED (ON=1, OFF=0)
Current Laser LED (ON=1, OFF=0)

bits that are always zero are indicated by a '0' under the bit position

Figure 8 - Status bits

NOTE: The sample above models the bits from Least Significant Bit (bit 0) to Most Significant Bit (bit 31). This is a right to left configuration which most programmers use. Some Modbus PLC item names model the bits of the registers as left to right configuration with the MSB as bit 1(not 0) and the LSB as bit 32 of a double register. This is important to remember when specifying bits from the status registers.

The above description of the 32 status bits is only valid for real data. In the case of forced data, all bits except bit 31 can be whatever the user sent to be used as forced data. Bit 31, however, will always be set to 1 by the unit's firmware so the data can always be identified as forced.

Bad laser or flow status conditions that persist for at least 2 seconds are latched and will be reported in the quality and status condition bits. The sample quality bit will be bad if flow or laser is bad, if the unit is in standby mode, or when the first sample has not yet completed.

The average flow words simply represent the average flow for the sample time and is represented in Percentage of flow. It is a calibrated value and will be very similar from sensor to sensor. The upper flow register always has a value of 0. The value of the lower register will most likely be near 100 (64_H).

Upon receiving the command, the unit will send back the first 2 bytes of the command string, then a byte whose hex value is the number of bytes to be returned (twice the number of holding registers to be read), then the requested data bytes.

8.6 SEND FORCED DATA

A 2 byte address for the starting forced holding register must be between 26 ($1A_H$) and 51 (33_H), then a 2 byte hex value of the number of registers being written to (must be between 1 and 26($1A_H$)), then a single byte hex value of the number of data bytes being sent (must be twice the number of registers being written to, since each register is 2 bytes long), followed by the forced data itself (must be careful not to mistakenly send data beyond register 51).

> Example: set rolling fine counts=21000(00 00 52 08 hex), rolling coarse counts=12000(00 00 2E E0 hex), status perfectly good, current flow + laser good, 1 ft^3, flow number=99, sample counter=5, sentinel counter=257(00 00 01 01 hex):

01 10 00 1A 00 0C 18 00 00 52 08 00 00 2E E0 00 00 77 7F 00 00 00 63 00 00 00 05 00 00 01 01

The command breaks down visually as follows:

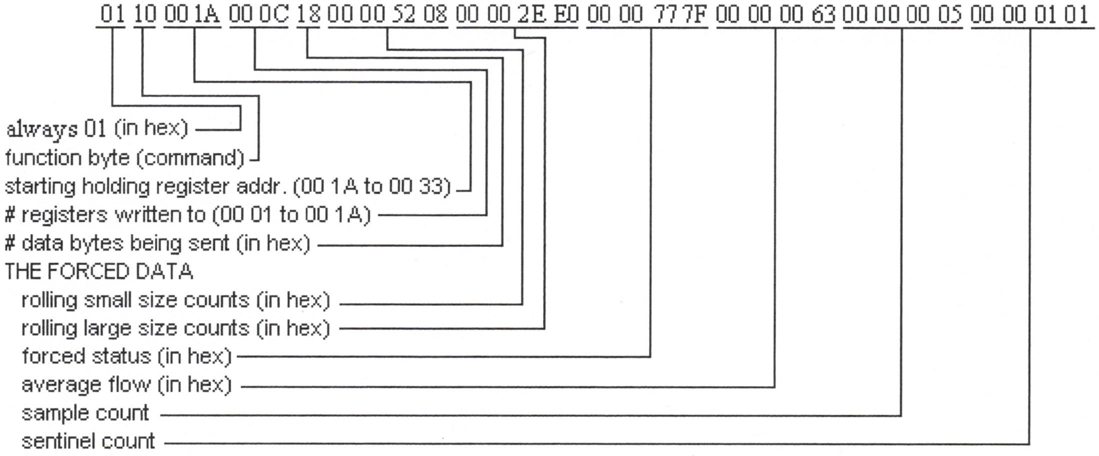

01 10 00 1A 00 0C 18 00 00 52 08 00 00 2E E0 00 00 77 7F 00 00 00 63 00 00 00 05 00 00 01 01
always 01 (in hex)
function byte (command)
starting holding register addr. (00 1A to 00 33)
# registers written to (00 01 to 00 1A)
# data bytes being sent (in hex)
THE FORCED DATA
rolling small size counts (in hex)
rolling large size counts (in hex)
forced status (in hex)
average flow (in hex)
sample count
sentinel count

Figure 9 - Command requesting forced data

Upon receiving the command, the unit will send back the first 6 bytes of the command string. It is important to note that bit 31 of the status words sent by the user will be set to 1 by the firmware, regardless of its value. This is to ensure that when the forced data is sent out, the real/forced bit will be 1, indicating the data is forced.

8.7 ECHO BACK A 16 BYTE TEST ARRAY (A DIAGNOSTIC FUNCTION)

A 2 byte value of 04 00 (always) followed by 16 bytes of the user's choice.

Example: echo back to unit: 01 08 04 00 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F

Upon receiving the command, the unit will send back the entire command string.

8.8 CLEAR COUNTERS AND RESET SAMPLE TIMER

A 2 byte value of 04 01 (always).

Example: clear and reset unit: 01 08 04 01

Upon receiving the command, the unit will send back the entire command string, then a zero byte (00).

Provided the unit is in active mode when it receives this command, the interval counter, sample counter, and average flow are all set to zero. The status is initialized to "error free" as if the unit had just powered up into the active mode. The interval, rolling, and sample counts are all set to -1 and the unit begins sampling a new sample volume. If the command is received while the unit is in standby mode, all of the above still happen. However, the unit remains in standby mode and the status becomes zero.

8.9 SEND UNIT ID

A 2 byte value of 07 D0 (always).

Example: send unit ID: 01 08 07 D0

Upon receiving the command, the unit will send back the entire command string, then a byte whose value represents the number of characters in the unit's ID (0 to 16 characters), then the actual ID string.

8.10 SEND UNIT MODEL NUMBER

A 2 byte value of 07 D1 (always).

Example: send unit model number: 01 08 07 D1

Upon receiving the command, the unit will send back the entire command string, then a byte whose value represents the number of characters in the unit's model number (always 16 characters), then the actual model number string (example 'CI-3100-21-1-4-6').

8.11 SEND UNIT FLOW RATE

A 2 byte value of 04 05 (always).

Example: send unit model number: 01 08 04 05

Upon receiving the command, the unit will send back the entire command string, then a byte whose value represents the number of characters in the unit's flow rate (7 to 9 characters), then the actual flow rate string (example '1.0 CFM').

9 EU Declaration of Conformity

Measurement, Control, Laboratory, and Industrial Equipment

EU Directives covered by this declaration: 89/336/EEC EMC Directive
2006/95/EC Low Voltage Directive
And all corresponding, amending Directives.

Product: Laser Particle Counter
Model: CI-3100-21
Version: EthernetModbus

Standards To Which Product Conforms: EN61326-1: 2006 Class A
EN61010-1: 2010 Class I

European Contact: Mike LeGrys
Thermotron
3 Heard Way
Eurolink Industrial Estate
Sittingbourne
Kent ME10 3SA England

I the undersigned hereby declare that the equipment specified above conforms to the directives and standards.

Place: Redlands, California USA

Date: January 21, 2013

David L Chandler

David L. Chandler
Engineering Manager

Attention

The attention of the purchaser, installer or user is drawn to the special measures and limitations which must be observed when the product is taken into service, in order to maintain compliance with the above directives. Details of the special measures and requirements are detailed in this product's user manual.

Two Year Warranty

Climet Instruments provides equipment for cleanroom monitoring and related applications. These products are designed to be rugged and provide reliable performance under normal use.

WARRANTY

Climet warrants that the products will perform according to stated specifications, and that the products will be free from defects in workmanship and materials. The warranty is for a period of 24 months. It does not cover misuse or abuse of the product.

The warranty does not cover damage or compromised performance resulting from the use of unauthorized parts or unauthorized modifications to the instrument. Expendables, including batteries and filters, are excluded from the 24-month warranty.

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Claims under the terms of this warranty must be submitted in writing within a period not exceeding 24 months of operation of the product, nor exceeding 25 months following the date of shipment of the product from the Climet factory.

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